Micro Systems Applications in Biotechnology and Health Care

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1 Introduction

After the commercialisation of MEMS (Micro Electro Mechanical Systems) in general, the fields of biology and medical care are about to create a new big market for micro systems. Biomedical applications mean both biotechnology and medical applications. The combination with micro system technologies is called BioMEMS, micro systems for biomedical applications.

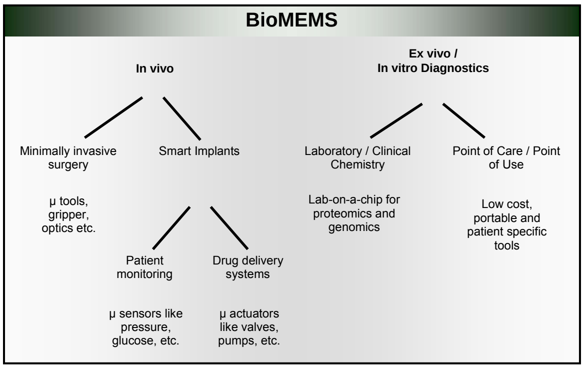

Fig.1: BioMEMS – a survey

2 *In Vivo* applications

From the *in vivo* application fields shown in Fig. 1, some essential requirements like small device dimensions, high reliability and durability, a high level of integration, and special durable biocompatible packages for *in vivo* MEMS devices can be derived.
Despite of the last one, all these points would be fulfilled by classical silicon based micro systems or other established technologies (like microelectronics).
For example implantable pressure sensors are being developed. Potential applications for such sensor implants will be the continuous monitoring of the pressure of blood, eyes or bladder. [1][2]
Other sensor developments with high impact are implantable glucose sensors for diabetes patients. These sensors would be able to monitor the glucose concentration in the blood in real-time, hence making self-testing several times a day unnecessary. This would bring a new standard of living for the increasing number of diabetes patients.
However, a challenge for the usage of micro systems in these applications is that sensors as well as actuators have to have direct contact with the human body. Thus, “encapsulation” of the sensor by cells or degradation of the sensing surface layer is one of the biggest problems to be solved. At present, subcutaneous implantation of the glucose sensors seems to be the most promising alternative. Several companies have already started to follow this route, but a real break through for long term application has not come yet. [3][4]
From this simple example it can be seen, that biocompatible packaging issues are one of the most challenging problems for the *in vivo* application of micro systems. Solving these problems can be the necessary impulse needed for commercialization of a great variety of micro systems for *in vivo* applications. Therefore, strong interdisciplinary research in the area of biocompatible packaging is necessary.
Once these problems have been overcome, future developments will combine these sensor technologies with micro scaled actuators like drug delivery systems. Larger implantable systems, especially for insulin dosage are already available on the market.

3 *In Vitro* applications

In some of the i*n vitro* application fields shown in Fig. 1 (especially point-of-care) the same kinds of sensors as for the above mentioned prostheses are applicable. These sensors could be pressure, acceleration, angular rate, vibration and inclination sensors that monitor the current “state” of patients or of elder persons.
The bigger share of in vitro applications is diagnostics, mainly *point-of-care* diagnostics and novel analytical systems for in-lab use. For both a high need for disposable systems is recognized. Disposable systems in general should be cheap,

thus material selection and their processing has to be cost-effective.

In general, *point-of-care* sensor systems have to be easy to use, while for in-lab systems high throughput analysis is important. However, in both cases sensors have to interact with biological samples. Due to the reasons outlined above, the following general properties and requirements for disposable micro systems in biotechnological applications (mainly sensor systems) could be derived:

- larger sensing area or parallel analysis necessary to overcome statistical uncertainty , to improve cross sensitivity or to enable the device for parallelisation
- low material price, since batch processing is limited due to minimal possible sensor size
- low technological processing costs
- sterilization is still critical for these applications (which is one of the reasons for the devices to be disposable)
- Chemical and biological compatibility with conventional systems and reagents

Most of these points can be better fulfilled by other materials than silicon. Especially polymers play a major role for disposable devices, but their processing in micro scale is not that far developed yet as for silicon based devices.

Another advantage of polymers is their lower price compared to silicon, and the possibility to precisely replicate polymer devices using technologies like hot embossing [5], micro injection moulding and UV casting.

First developments therefore concentrated on applications for simple micro structured polymer substrates.

Due to the ease of polymer structuring and their optical transparency, it is comparably easy to integrate passive optical parts like waveguides, gratings or lenses. Since optical detection methods play a major role in biotechnology integrated optics can bring a new quality to micro structured devices for applications in biotechnology.

The evolution of polymer electronics, polymer based electro-optical components and electrically deformable polymers could bring up a new generation of disposable polymer based sensor systems for biomedical applications. Such sensor systems would include also active optical sensing components and fluid actuation components for sample preparation and sample transport. Especially in the point of care fields, where accuracy is not as important as in laboratories, these sensors developments could have a high potential due to their combination of comparative price for high volumes and high functionality.

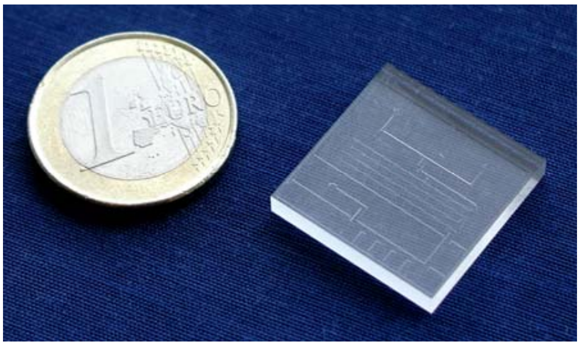

Fig.2: Polymer chip with micro structured fluidic channels and integrated optical waveguides

4 Conclusions

BioMEMS will have a high impact to in vivo as well as in vitro biomedical markets. Especially both fields implantable miniaturized systems and low cost analysis chips as shown are preferred markets for micro systems. However, the main challenges are not arising from the field of micro technology, but from the interface between biological and technical systems.

5 References

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